THE BEHAVIOR OF *CHLOROCHROA LIGATA* (SAY) AND *COSMOPEPLA BIMACULATA* (THOMAS), (HEMIPTERA:PENTATOMIDAE)[1]

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The behavior of relatively few pentatomid stinkbugs has been reported in any detail. Nevertheless; the accounts of their activities that do exist indicate that the courtship and mating activities of these insects are highly diverse and worthy of study (Kullenberg, 1947; Teyrovsky, 1949; Southwood and Hine, 1950; Leston, 1955; Southwood and Leston, 1959; Kaufmann, 1966; Mitchell and Mau, 1969; Tostowaryk, 1971). Recently one of us discovered a species (*Euschistus conspersus* Uhler) that initiates copulation with the male facing directly away from the female as he inserts his aedeagus (Alcock, 1972). To the best of our knowledge, this behavior has been recorded for a pentatomid only once previously (Mitchell and Mau, 1969) and would appear to be rarely practiced by the Heteroptera in general (Weber, 1930; Grasse, 1951). Typically male bugs mount the female inserting the aedeagus while facing in the same direction as their mate before dismounting to turn 180° away from the female. This paper reports our observations of mating and some other activities by two species of Pentatomidae.

Chlorochroa ligata

This is one of the commonest of all *Chlorochroa* and is abundant in the Seattle area especially in blackberry patches (*Rubus laciniatum*). This species was studied in the laboratory and field from mid-May 1972 through mid-August 1972. The primary field location consisted of a dense blackberry tangle near the University of Washington campus in Seattle, Washington. In addition, groups of bugs were kept in a 5 gal. terrarium and fed green beans.

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Mating occurred primarily in the late afternoon (fig. 1). Females were approached by males sometimes while the former were feeding. A male would (1) tap the female with its antennae and (2) then begin to lift the rear part of her abdomen with its head in short pushes. This caused the male's body to jerk rapidly. Sooner or later the male would move directly behind the female vigorously patting the underside of her abdomen with his antennae. At this time the male's aedeagus was often extruded sufficiently to show a black ring at its base. Receptive females responded by lowering their head until it touched the surface on which they were standing. This of course has the effect of elevating the female's entire abdomen. The male would then turn, lift his abdomen, and back into the female inserting his aedeagus into her genital opening. After copulation is initiated the male lowers his abdomen somewhat pulling that of the female downward. An encounter might lead to a copulation in as little time as two minutes. Males confronted with an unreceptive female might continue to court for as long as 30 min. Almost always three or more bugs were present during a courtship and at one time three mated pairs were observed within 25 cm of one another. This suggests the release of an attractant by the female presumably.

After mating the male rests both hindlegs on the tibia or tarsi of the hindlegs of the female. Males often feed during copulation while females exude drops of clear liquid from their rostrum which is rigidly extended or bent rather than folded against the thorax in its resting position. Pairs remain mated for 2-2½ hr. based on three field observations. A total of eight courtships resulting in copulations were seen during the study.

Reproduction was well under way by mid-May and continued through to the first week of August. However, by the second week of this month almost all adults had died and the second generation nymphs were becoming increasingly abundant.

Ten clusters of eggs were laid in the terrarium with an average number of 32.5 (range, 8-56). A cluster of 27 eggs was found on the underside of a blackberry leaf in the study area. Two clutches required a mean number of 12 days to hatch and another 58 days to reach adulthood.

The first and second instars formed tightly packed contact

clusters in the terrarium but this behavior was much less pronounced in the later stages of development. In the field the nymphs remained in a tight cluster about one cm from the egg cases for the first five days after hatching but by the sixth day they had dispersed somewhat.

The peak population of the second and third instars occurred at the same time large numbers of blackberries came into season. The nymphs, a brilliant black with yellow borders, are quite cryptic against this background.

Feeding behavior

C. ligata is a generalist feeder attacking dried and fresh blackberries, the main and secondary veins of blackberry leaves, blackberry stems, grass stems and grass seeds. In addition, one bug was watched while feeding on a morning glory seed pod and another was seen with a group of about sixty *E. conspersus* adults feeding on a stem of the bracken fern *Pteridium aquilinum.* This is then the second species of pentatomid known to feed on a fern (Alcock, 1972). Feeding occurs primarily in the morning and evening (fig. 1).

Basking behavior

Like *E. conspersus* (Alcock, 1972), *C. ligata* basks conspicuously on the exposed upper surfaces of blackberry leaves, particularly in the morning with a secondary peak in the late afternoon (fig. 1). During these times bugs often tilt so that their green back is oriented at right angles to the sun, probably the optimal surface for absorbing heat. At the middle of the day during sunny hot spells the bug is rarely seen in exposed areas. Several that were in the open had tilted their bodies so as to expose the minimum back surface area to the sun.

Grooming behavior

In addition to a variety of movements involving the use of the tarsi and claws to clean portions of the legs, the antennae, the edge of the abdomen, and the aedeagus, this species, as well as *E. conspersus* (Eric McPherson, pers. comm.; pers. observation) and *Cosmopepla bimaculata,* employs an interesting claw-washing behavior. Resting bugs sometimes exude a small drop of fluid from the tip of the rostrum and place it on any one of a number of

combinations of two or three claws held closely together. The two front claws, the two front and one middle claw, one front and one middle claw, or one middle and one hind claw are anointed and then rubbed smartly together.

Because the amounts used were very small in all three species and difficult to collect, it was not possible to analyze the cleaning fluid directly. However, on the supposition that the substance expelled by *C. ligata* females during mating might be the same as the cleaning liquid for this species, it was collected in capillary tubes and analyzed with the help of John Edwards. No precipitate formed when the liquid was mixed with concentrated acetic acid and ethyl alcohol indicating no significant protein content. No bubbles formed when the liquid was blown into showing that it was not a surface active detergent. No significant amounts of precipitate formed when silver nitrate was added; the solution was not saline.

The fluid is most likely water. Pressure on the abdomen during mating probably causes excess water in the gut to be absorbed by the salivary glands and excreted through the rostrum. If this is the fluid used during claw-washing, and there is no guarantee that it is, it has no special cleansing action. Even so, water presumably is an effective aid in the removal of dust particles and other debris that might reduce the adhesive properties of these bugs' claws.

Dispersal of adults

Groups of adult bugs in six zones (200 m stretches along a railway track through the blackberry patch) were marked with acrylic paint dots placed on the thorax using a code that identified the zone in which they were originally found. A total of 89 bugs were marked with observations continuing for 21 days. Up to eight marked individuals were seen as late as 10 days after marking. However, never more than a single pentatomid was seen outside its original area. It would appear that few bugs wander widely although they are quite capable of flying 10 m or so and were rather frequently observed in flight, especially in the early afternoon (fig. 1).

C. ligata, E. conspersus, and *C. bimaculata* engage in both silent flight and "buzz" flight. In the first two species buzz flight produces sounds reminiscent of a bee and so may deter some aerial

predators from attack. This can hardly be the case for *bimaculata,* a much smaller animal with much quieter flight. The significance of silent flight is uncertain.

Cosmopepla bimaculata

This species was observed briefly in the field in late May at Flaming Geyser State Park near Auburn, Washington. It was found in scattered groups in pastures and open areas feeding on buttercups. In addition, a group of about fifteen was collected and observed in a terrarium where they were maintained on their natural foodplant.

Reproductive behavior

Unfortunately no complete mating was ever seen in about 30 hr. of watching. However, a very large number of unsuccessful courtships were observed and from these a picture of courtship and the probable manner of copulation emerges.

Females standing on plant stems or feeding on buttercup pods were often approached by males. These often assumed a "waiting position" with their head touching the underside of the female's abdomen or thorax. Often several minutes elapsed before the next action which was a very active, rapid tapping of the female with the male's antennae. Males frequently moved quickly from one side of the female to her head and then back to the thorax. They might completely circle the potential mate on occasion, antennating furiously all the while. Generally males eventually oriented these rapid patting movements to the tip of the female's abdomen.

Antennation was followed by very quick butting movements by the male apparently designed to lift the abdomen of the female upward. These were usually directed at the rear part of the female. After a brief period (5-10 sec.) of butting during which time the male literally vibrates he turns around with aedeagus fully extruded and inverted. At this stage his body forms an angle of between 180° (often) to 90° with the female's body. When contact was made, the male's aedeagus moved rapidly side to side; again the male appears to vibrate his actions are so rapid. It seems highly likely that copulation is initiated in this end-to-end position although this was not verified because the females always proved to be unreceptive despite dozens of observed attempts to copulate by males.

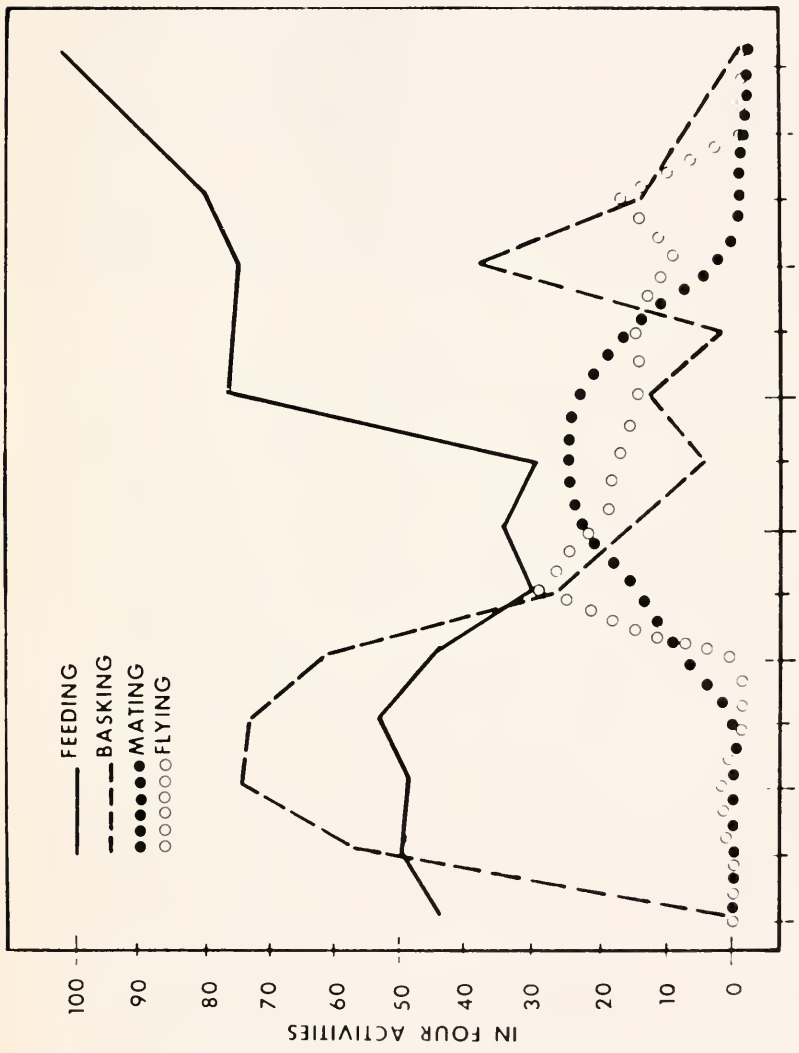

Fig. 1. A graph showing the daily activity pattern of *Chlorochroa ligata*. Notice that basking and feeding occur primarily in the early morning and evening. The bugs move about most at mid-day and mate in the afternoon.

Females signalled their lack of receptivity by moving away from the male or by pushing a suitor away with a firm deliberate kick given by the hind legs. When a female walked off a male might follow for as much as 25 cm. Sometimes males overtook a female and courted her once more. Other times the bug would retrace its path to the spot where courtship had begun. Females were seen returning to these areas some time later; they were courted again by the males that remained behind.

The failure to observe mating, despite the fact that mated pairs were often seen and despite the many hours of watching between 09.00 and 17.00, suggest that copulations may occur largely in the evening or possibly at night.

Discussion

Assuming that *C. bimaculata* does copulate directly in an end-to-end position there are now a variety of pentatomids representing several genera, including *Nezara* (Mitchell and Mau, 1969), that are known to employ this pattern. Dr. R. I. Sailer informs us that he has observed this behavior in *Euschistus variolus* and *E. servus* as well as in some species of *Thyanta.* Thus this manner of mating may be common among the Pentatomidae. It is perhaps surprising that what is really rather complex courtship and mating behavior should be so similar across genera. Those courtships we have studied all include: (1) male taps the female's body with its antennae, (2) male strokes underside of the female's abdomen with its antennae, (3) male lifts the female's abdomen with its head, and (4) male backs into the female often in response to elevation of her abdomen. Differences have been primarily quantitative (such as the rapidity of antennal tapping) rather than qualitative. It may be that these similarities are the product of convergent evolution with selection for male behavior patterns that are effective in inducing the female to adopt a position (abdomen raised) that facilitates insertion of the aedeagus. Additional comparative data on other pentatomids would be extremely useful in answering this question as well as providing evidence on the taxonomic relationships within the family and the probable evolution of the distinctive courtship behaviors that are practiced by members of the group.

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ABSTRACT.—The courtship and copulatory behaviors of two species of pentatomid bugs, *Chlorochroa ligata* and *Cosmopepla bimaculata* are described. These species provide one certain and another probable example of pentatomids in which the male initiates copulation, following courtship, while facing directly away from the female. Information on the daily activity cycle of *C. ligata* in Seattle, Washington is presented. This bug has been seen feeding on a fern, *Pteridium aquilinum.* Both stinkbugs engage in elaborate claw-washing behavior in which regurgitate, possibly water, is applied from the tip of the rostrum to various combinations of claws which are then rubbed together. Similarities in the courtship sequence employed by members of four separate genera of

Pentatomidae are outlined followed by a speculation on the significance of this pattern of mating.

Descriptors: Hemiptera; Pentatomidae; courtship and mating behavior; *Cosmopepla bimaculata* (Thomas) and *Chlorochroa ligata* (Say).

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INTERACTION BETWEEN A WESTERN HARVESTER ANT AND A GREAT BASIN SAGEBRUSH LIZARD

On 30 September 1972 a Great Basin sagebrush lizard, *Sceloporus graciosus graciosus* Baird and Girard, was collected 20 km NW Reno, Washoe County, Nevada, at an elevation of 1585 m. The lizard (3.5 cm snout-vent length and 1.7 g live weight) was collected by hand along a gravel road edge in a dense patch of *Salsola kali.* The head of a western ant, *Pogonomyrmex occidentalis* (Cresson), was found attached to the middle of the fifth toe of the lizard's right fore leg. This ant is abundant in the area, having nest densities of up to 42 per hectare. It is not known if the harvester ant attacked the lizard in self-defense or as an active predator.

Examination of the stomach and intestinal contents of this lizard revealed that 4 ants (none could be recognized as *Pogonomyrmex),* 1 other Hymenoptera, 2 Hemiptera, 1 Homoptera (Aphididae) and 2 Coleoptera (Carabidae and Curculionidae), along with several grains of sand had been ingested. Knowlton (1942; 1953) and Knowlton and Valcarce (1950) report *S. g. graciosus* feeding on *P. occidentalis* in Utah.

No reference to *P. occidentalis* attacking living reptiles under natural circumstances could be found. In the laboratory Knowlton (1946) found that this ant readily attached to various areas including the toes of a living individual of the northern desert horned lizard, *Phrynosoma platyrhinos platyrhinos* when the two were placed together in a container.

The lizard with attached ant head is in the collection of the author, #504.

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